



## Subsurface Challenges

Mastering the subsurface for energy production and storage and for the management of energy waste streams constitutes a substantial energy challenge. The Department of Energy (DOE) is implementing a new collaborative model to address the following common subsurface challenges:

### 1. Discovering, Characterizing, and Predicting

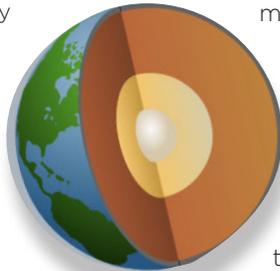
- Accurately characterizing the subsurface using integrated geophysical and geochemical technologies
- Quantitatively inferring subsurface evolution under current and future engineered conditions
- Finding viable, low-risk resources

### 2. Accessing

- Safe, cost-effective drilling and completions with properly managed wellbore integrity

### 3. Engineering

- Creating/constructing desired subsurface conditions in challenging high-pressure/high-temperature environments



### 4. Sustaining

- Maintaining optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution

### 5. Monitoring

- Improving observational methods to advance the understanding of multi-scale complexities through system lifetimes



## Why is the SubTER Crosscut Important?

Subsurface energy sources satisfy over 80% of total U.S. energy needs. Finding and effectively exploiting these resources while mitigating impacts of their use constitute major technical and socio-political challenges. Still, the opportunities are vast. Next generation advances in subsurface technologies will enable increases in domestic natural gas supplies, as well as 100+ GWe of clean, renewable geothermal energy. The subsurface provides hundreds of years of safe storage capacity for carbon dioxide (CO<sub>2</sub>), and opportunities for environmentally responsible management and disposal of hazardous materials and other energy waste streams. The subsurface can also serve as a reservoir for energy storage for power produced from intermittent generation sources. These opportunities have immediate connection to societal needs and Administration priorities. Clean energy deployment and CO<sub>2</sub> storage are critical components of the President's Climate Action Plan, necessary to meet the 2050 greenhouse gas (GHG) emissions reduction target. Increasing domestic energy supply from greater hydrocarbon resource recovery, in a sustainable and environmentally sound manner, is also an Administration goal that enhances national security and fuels economic growth.

## JASON Letter Report on State of Stress in Engineered Subsurface Systems

A new report prepared for SubTER by the independent JASON advisory group recommends that **“DOE take a leadership role in the science and technology for improved measurement, characterization, and understanding of the state of stress of engineered subsurface systems in order to address major energy and security challenges of the nation.”** JASON recommends coordinated research and technology development at dedicated field sites to connect insights from laboratory scales and models to operational environments.

Read the JASON Report at [www.energy.gov/articles/2014-jason-report-state-stress-engineered-subsurface-systems](http://www.energy.gov/articles/2014-jason-report-state-stress-engineered-subsurface-systems)

## Learn more about SubTER

[www.energy.gov/subsurface-tech-team](http://www.energy.gov/subsurface-tech-team)

## Contact us

[Subsurface@hq.doe.gov](mailto:Subsurface@hq.doe.gov)

## Who's Involved?

Representing the geosciences, research, modeling, technology development, policy, and stakeholders, the participating DOE program and staff offices include:

- |                                      |   |
|--------------------------------------|---|
| Fossil Energy                        | ARPA-E                                    |
| Energy Efficiency & Renewable Energy | Electricity Delivery & Energy Reliability |
| Nuclear Energy                       | Energy Policy & Systems Analysis          |
| Environmental Management             | Congressional & Intergovernmental Affairs |
| Science                              | Energy Information Administration         |

## SubTER Pillars

Through ongoing engagement with key stakeholders to help identify high priority technology areas for federal advancement, DOE has developed a comprehensive RD&D strategy focused around four core pillars:

**Wellbore Integrity** – New sensors and adaptive materials are needed to ensure sustained integrity of the wellbore environment.

**Subsurface Stress & Induced Seismicity** – Radically new approaches are needed to guide and optimize sustainable energy strategies and reduce the risks associated with subsurface injection.

**Permeability Manipulation** – Greater knowledge of coupled processes will lead to improved methods of enhancing, impeding, and eliminating fluid flow.

**New Subsurface Signals** – DOE seeks to transform our ability to characterize subsurface systems by focusing on four areas of research: new signals, integration of multiple data sets, identification of critical system transitions, and automation.

A critical component of all pillars will be R&D testing at **Energy Field Observatories**. Field tests are critical to the validation of new results and approaches at commercial scale to validate tools, technologies, and methodologies and measure progress.

## Upcoming Events

**GSA 2015 Annual Meeting**,  
Nov. 1-4, 2015, Baltimore, MD

**AGU 2015 Fall Meeting**,  
Dec. 14-18, 2015, San Francisco, CA

**AAPG 2016 Annual Meeting**,  
June 19-22, 2016, Calgary,  
Alberta, Canada

## Past Events

**SubTER Grand Challenge Workshop:**  
*Imaging Geophysical and Geochemical Signals in the Subsurface*, July 21, 2015.

**DOE Crosscutting Subsurface Initiative:**  
*Adaptive Control of Surface Fractures and Flow* Town Hall, June 2, 2015,  
5:10-6:40 pm American Assoc. of  
Petroleum Geologists, Denver, CO

**BES - Roundtable Discussion on Foundational Research Relevant to SubTER**, May 22, 2015, Germantown, MD



With nearly 100 Quadrillion Btu of energy generated by oil, natural gas, coal, nuclear, and geothermal, the Earth's crust affects the greater part of all domestic energy supplies.

## Recent Activities

In May 2015, the DOE held a Grand Challenge workshop to discuss imaging geophysical and geochemical signals in the subsurface. The success and synergy of the workshop lead to a follow-up roundtable in July 2015. These two events convened national lab, university, and industry experts to brainstorm research areas that underpin the Pillars of SubTER. The outcome of these meetings resulted in the identification of prioritized research questions that will help inform future research directions.

### National Laboratory Early-Phase Research

Approximately \$9M has been awarded by the EERE-Geothermal Technologies Office and Office of Fossil Energy to national laboratory teams to begin work on crosscutting topics. These projects are envisioned to feed into broader program efforts in upcoming years:

*Lawrence Berkeley National Laboratory:* Hydraulic Fracture and Stimulation in a Deep Mine Investigation. **PILLAR: Permeability Manipulation, Subsurface Stress & Induced Seismicity**

*Lawrence Livermore National Laboratory:* Development of microBayesloc Location Method. **PILLAR: Subsurface Stress & Induced Seismicity**

*Los Alamos National Laboratory:* Development of Novel 3D Acoustic Borehole Integrity Monitoring System. **PILLAR: Wellbore Integrity**

*Los Alamos National Laboratory:* Multi Variate Examination of the Cause of Increasing Induced Seismicity. **PILLAR: Subsurface Stress & Induced Seismicity**

*National Energy Technology Laboratory:* Big Data and Analytics for Induced Seismicity. **PILLAR: Subsurface Stress & Induced Seismicity**

*Oak Ridge National Laboratory:* Photo-stimulated luminescence spectroscopy stress sensor for in-situ stress measurement. **PILLAR: Subsurface Stress & Induced Seismicity**

*Oak Ridge National Laboratory:* Ultrasonic Phased Arrays and Interactive Reflectivity Tomography. **PILLAR: Wellbore Integrity**

*Pacific Northwest National Laboratory:* Borehole muon detector for 4D density tomography of subsurface reservoirs, geophysics, hydrology, geochemistry, and biochemistry. **PILLAR: New Subsurface Signals**

*Sandia National Laboratories:* Imaging Fracture Networks Using Joint Seismic and Electrical Change Detection Techniques. **PILLAR: Permeability Manipulation**